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Canadian Science Advisory Secretariat
Science Response 2016/027

Maritimes Region

SCOTIAN SHELF SILVER HAKE (NAFO DIVISIONS 4VWX) STOCK STATUS UPDATE FOR 2015-2016

Context

Advice on the status of the Scotian Shelf (4VWX) Silver Hake stock is requested annually by Fisheries and Oceans Canada (DFO) Fisheries and Aquaculture Management Branch to determine a Total Allowable Catch (TAC) consistent with the Integrated Fishery Management Plan (IFMP). The most recent assessment of Silver Hake was conducted in 2012 (DFO 2013). An analytical reconstruction of population trends based on commercial landings and research vessel (RV) survey data from 1993-2011 was developed through the framework process, using a logistic biomass dynamic model. Biological reference points were calculated from model outputs and included a median estimate of Maximum Sustainable Yield (MSY), Biomass at MSY (B_{MSY}), and Fishing mortality at MSY (F_{MSY}). The consequences and risk to productivity of the stock were evaluated under a number of harvest options (DFO 2013).

Since the 2012 framework assessment, science advice has been provided annually as a stock status update and published as a Science Response. The objective of the interim update is to report new information from the DFO Summer RV Survey, and commercial landings data. Recent trends in biomass (B) and fishing mortality (F) are evaluated against the values for MSY, BMSY, and FMSY derived in the framework assessment. The most recent update occurred in December 2014 (DFO 2015a).

This Science Response Report results from the Science Response Process of December 15, 2015, on the 2015 Stock Status Update for 4VWX Silver Hake.

Background

Biology

Silver Hake is a demersal member of the gadoid family occurring in the Northwest Atlantic Ocean from Cape Hatteras to the Grand Banks and the Gulf of St. Lawrence. Silver Hake are found in warmer water, with juvenile and mature hake associated with water temperatures between 5–12 °C and 7-10 °C, respectively. A population of Silver Hake occurs on the Scotian Shelf in Northwest Atlantic Fisheries Organization (NAFO) Divisions 4VWX (Figure 1). This population aggregates in deepwater depressions on the Scotian Shelf (Emerald and LaHave basins) and in the warm slope water, except during the spawning period from July-September when large aggregations occur on the shelf in shallow waters surrounding Emerald and Sable Island Banks. Silver Hake feed primarily on invertebrates, with euphausiids the predominant prey item. Older fish are piscivorous and exhibit a high degree of cannibalism. Silver Hake exhibit relatively rapid growth with females growing faster than males. Maximum age is 12 years. Maturity is relatively early, with the majority maturing at age 2. Further detail on Silver Hake biology is available in Stone et al. (2013).

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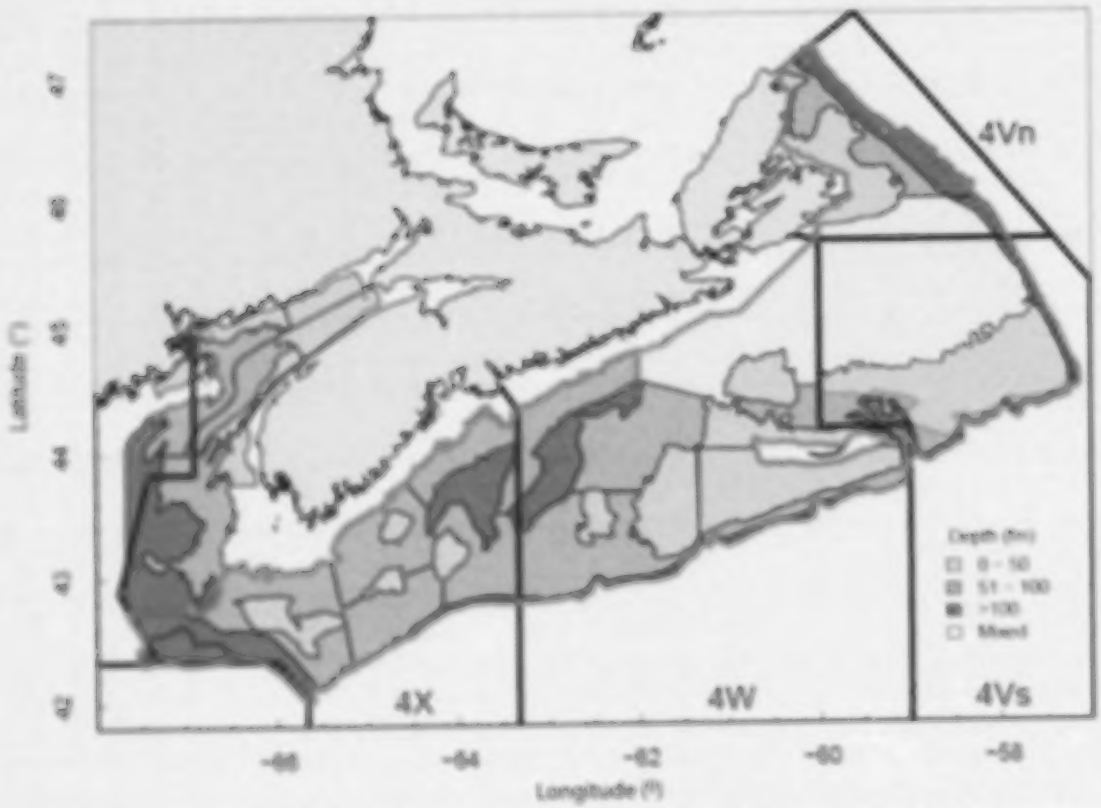

Figure 1. Northwest Atlantic Fisheries Organization (NAFO) Divisions 4VWX and associated DFO Summer Research Vessel Survey strata outlined in black and colour coding for depth ranges within a strata. The red outline represents the survey strata used to assess 4VWX Silver Hake.

Description of the Fishery

A significant fishery for Silver Hake across the Scotian Shelf (NAFO Divs. 4VWX) began in the early 1960s with the arrival of distant water fleets predominately from Russia, Japan and Cuba. Foreign fleets dominated the Silver Hake fishery until the mid 1990s when participation by Canadian travelers began (Showell and Cooper 1997). Since 2004, all catches have been from the Canadian mobile gear fleet using bottom trawls with 55 mm square mesh codends. Fishing is restricted to Emerald and LaHave basins, and the edge of the Scotian Shelf (Figure 1) seaward of the Small Mesh Gear Line. Further details on the history of this fishery are available in Stone et al. (2013).

The Total Allowable Catch (TAC) has been set at 15,000 metric tonnes (mt) since 2003, but landings have been lower, averaging 7,800 mt for the years 2010-2014. Consistent landings below the TAC are a consequence of market conditions and the reduced effort directed at this species, rather than abundance (Stone et al. 2013). Landings of Silver Hake in the fishing years ending in 2013 and 2014 were 7,800 mt and 6,900 mt, respectively. (Table 1, Figure 2). In recent years, most catches have been from Emerald and LaHave basins. Annual total landings from the Scotian Shelf outside of Emerald and LaHave Basins were zero from 2005-2010 and averaged 0.3 mt from 2011-2014 (Figure 2).

The 2015 fishing season is still ongoing, and landing statistics are incomplete.

Table 1. Landings and Total Allowable Catch (TAC) of Silver Hake in 4VWX ('x 103 mt)

Year	1970-79	1980-89	1990-99[3]	2000-09[4]	2010	2011	2012	2013	2014	2015
TAC	90.2[1]	98.5	53.3	16.5	15	15	15	15	15	15
Canada[2]	0	0	3.7	13.0	8.4	9.2	8.7	7.8	6.9	-
Foreign	115.6	64.2	27.8	0	0	0	0	0	0	-
Total	115.6	64.2	31.5	13.0	8.4	9.2	8.7	7.8	6.9	-

[1] Average TAC for 1974-79 period.
[2] Includes developmental allocations fished by foreign flagged vessels, ending in 2004.
[3] Fishing year, landings and TAC refer to the 15 month period from January 1, 1999, to March 31, 2000.
[4] Commencing in 2000, fishing year, landings and TAC refer to the period from April 1st of the current year to March 31st of the following year.

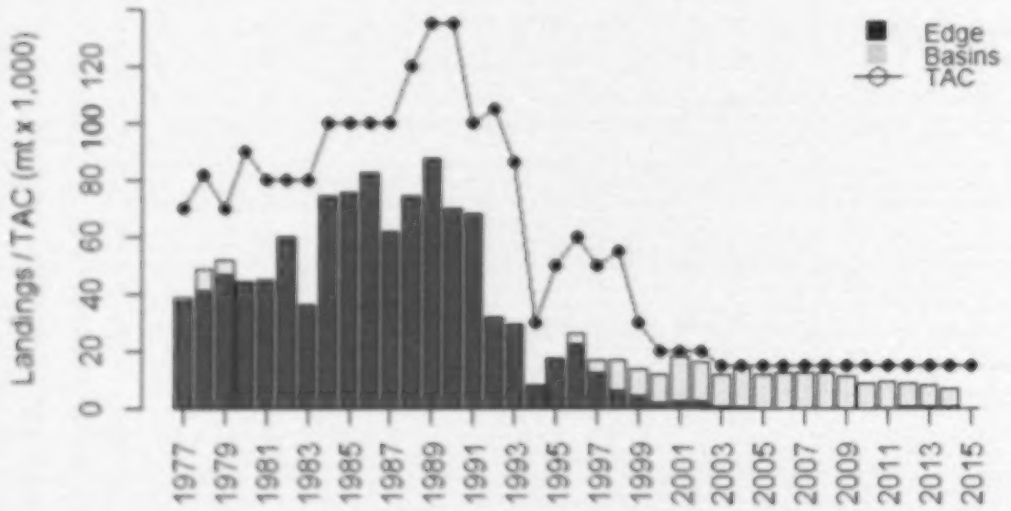

Figure 2. Silver Hake Total Allowable Catch (TAC) (line) and landings (bars) (x 103' mt) by fishing area, 1977-2015. Basin: landings from Emerald and LaHave basins. Edge: landings from the shelf edge and outside the basins.

Analysis and Response

4VWX RV Survey

Bottom trawl surveys of the Scotian Shelf have been conducted by DFO since 1970, using a stratified random sampling design to choose station locations. The longest running survey series covering the entire Silver Hake stock area is the DFO Summer RV Survey conducted in July. This survey provides information on Silver Hake numbers and biomass as well as estimates of year-class strength and recruitment.

Silver Hake biomass in the Summer RV Survey was highest in the early 1980s, but shows a decreasing trend from 1998 to 2008 (Figure 3). Biomass shows an increasing trend since 2009, and the biomass estimate for 2014 is the highest observed since the 1980s. In 2015, biomass declined approximately 30% to a level comparable to those observed in 2009, 2010, and 2013.

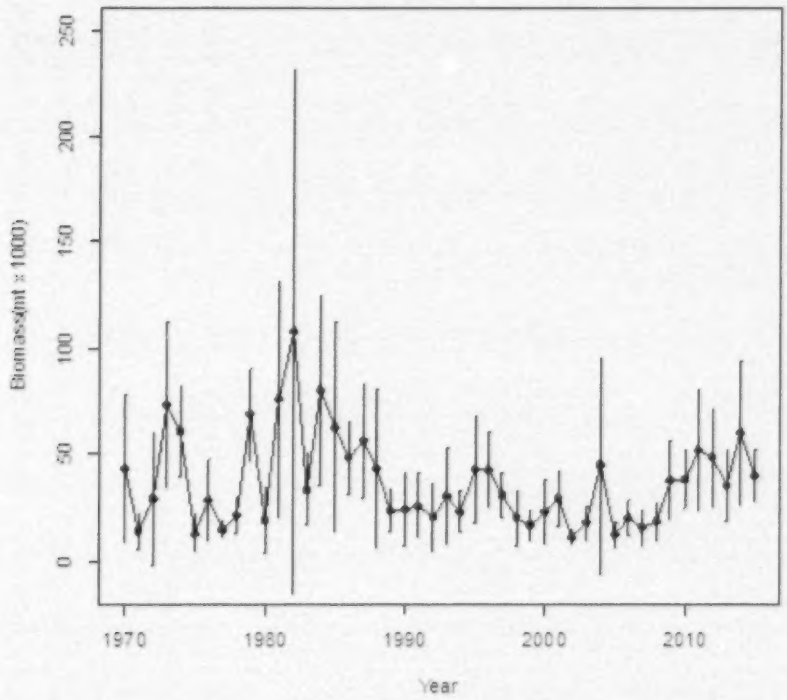

Figure 3. Stratified total biomass estimates from the DFO Summer RV Survey (excludes Bay of Fundy strata), 1970-2015. The vertical bars indicate a confidence interval of two standard errors.

Age data are not available for the 2014 or 2015 RV Surveys but year classes are visible as distinct modes in the survey length frequency data (DFO 2015b). Total stratified number of fish < 23 cm provides a proxy for age one numbers, and has been used as a recruitment index (Branton et al. 1997, Stone et al. 2013). Recruitment has been variable but generally above the long-term average in recent years (Figure 4). The 2012 year class was below average. The 2013 and 2014 year classes are large, almost three times the long-term average.

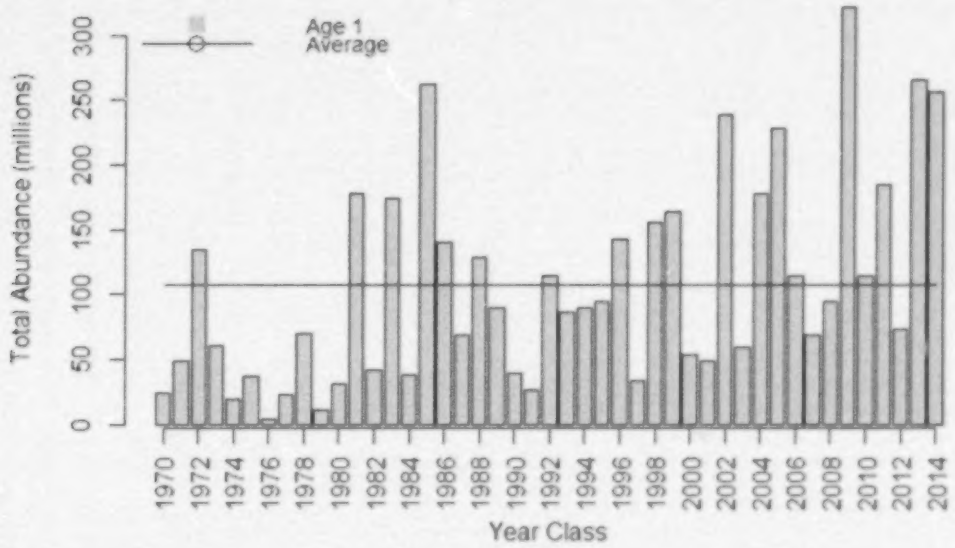

Figure 4. Age 1 abundance estimates for Scotian Shelf Silver Hake from the Summer Research Vessel (RV) Survey. The long-term average (1970-2015) is indicated by the solid horizontal line. The 2013 and 2014 year classes are estimated from RV survey length frequency data.

Population Modelling

During the Silver Hake framework assessment, a logistic biomass dynamic model was accepted as a basis for estimating population biomass (Cook 2013). The model fits commercial fishery landings to the q-corrected Summer DFO RV Survey index (1993-2015) to estimate trends in population biomass and fishing mortality.

Biological reference points for 4VWX Silver Hake stock estimated by the biomass model were accepted at the framework assessment (DFO 2013) as MSY: 16,000 mt; Biomass at MSY (B_{MSY}): 59,000 mt; and fishing mortality at F_{MSY} : 0.32. An Upper Stock Reference (USR) at 80% of B_{MSY} (47,200 mt), and a Limit Reference Point (LRP) at 40% of B_{MSY} (23,600 mt) were accepted. F_{MSY} was established as the Limit Removal Reference (0.32).

Biomass estimates from the population model have been above 99,000 mt since 2009. The 2014 estimate was the highest in the times series at 146,000 mt. Biomass declined slightly in 2015 to 122,000 mt (Figure 5).

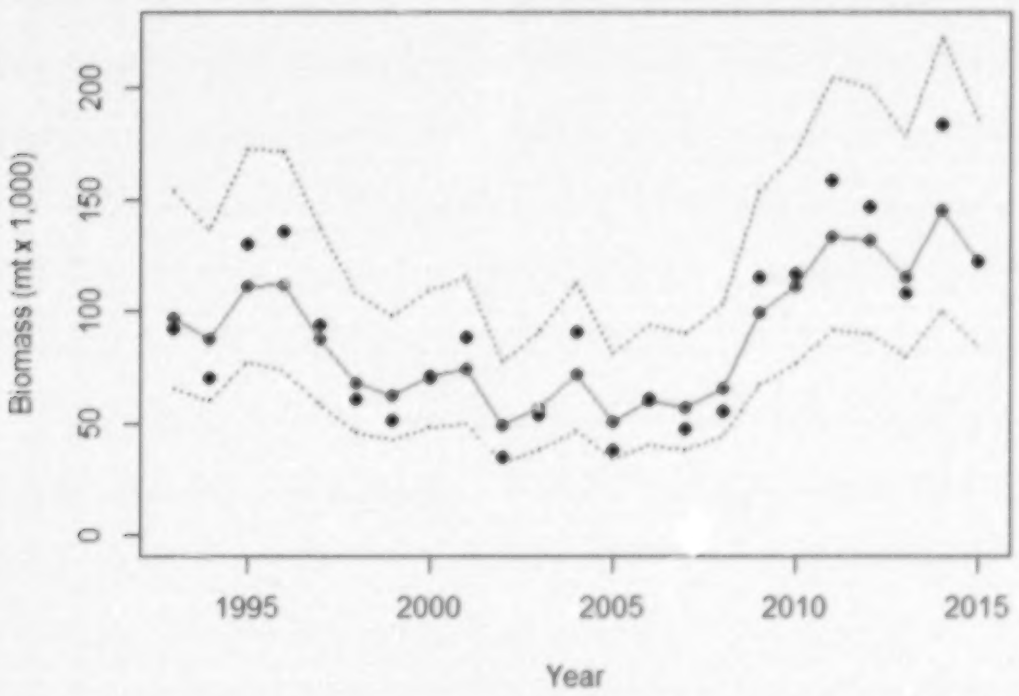

Figure 5. Model fits (blue line and points) to the q-corrected Summer Research Vessel Survey biomass index (black points) for Silver Hake (1993 – 2014). Dashed lines represent 50% credible intervals for model biomass estimates.

Updated model results incorporating recent landings to the end of the 2014 fishing year and the 2015 Summer RV Survey are illustrated in Figure 6. The most recent stock status report update projected an F of 0.06 with an estimated catch of 7,800 mt (DFO 2015a). Actual catches for this period were approximately 6,900 mt, for an estimated F of 0.06.

The relationship between stock biomass and exploitation (expressed as ratios of biomass and fishing mortality to B_{MSY} and F_{MSY}, respectively) is presented in Figure 6. For the period covered by the model (1993-2015), biomass has been above 80% of B_{MSY} and fishing mortality has been below the reference level F_{MSY}. Population biomass has declined, as anticipated in the 2014 stock status update (DFO 2015b), but remains above B_{MSY}.

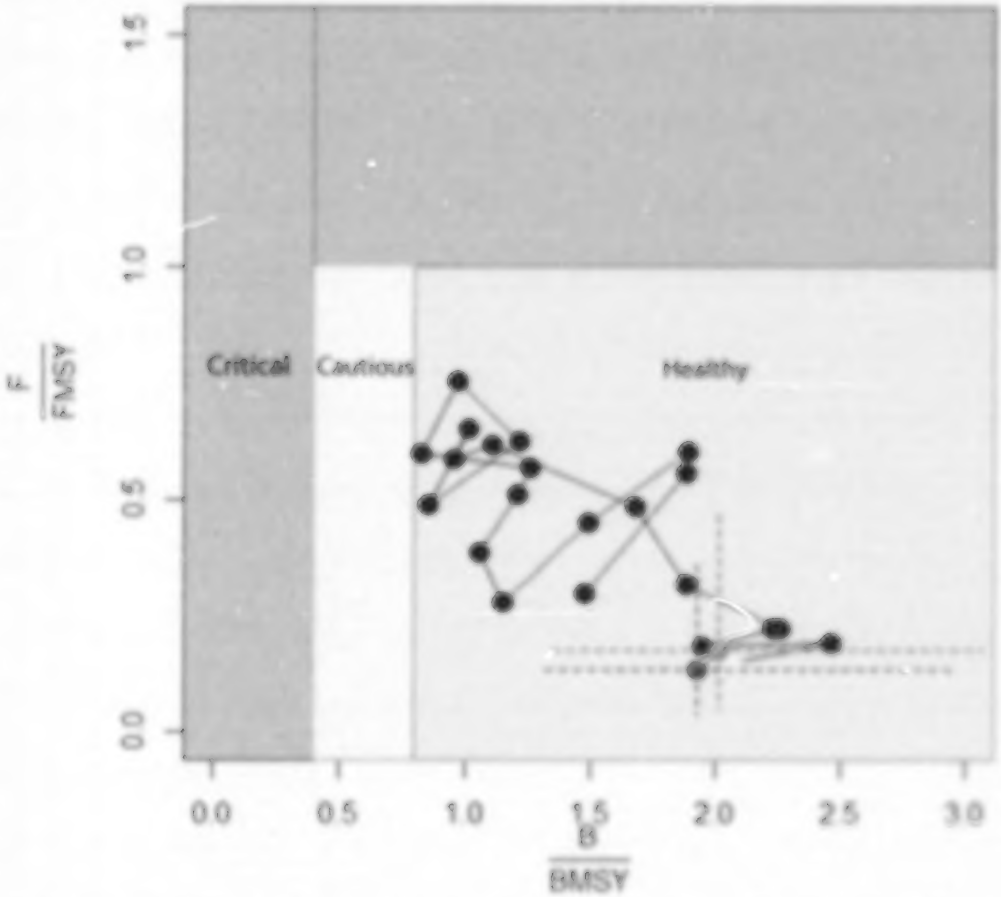

Figure 6. Phase plot of the ratio of fishing mortality (F) to FMSY, and biomass (B) to BMSY. Colours represent stock status: red-critical, yellow-cautious and green-healthy. The yellow dot represents the 2015 biomass and fishing mortality from the population model. The red dot indicates projected biomass and exploitation with an assumed catch of 7,500 mt for the July 2015 to June 2016 period. The blue dot represents projected biomass and exploitation at an assumed catch of 7,500 mt (status quo) from July 2016 to June 2017). The dashed lines are the credible 50% intervals around the projected estimates.

Four landings scenarios were explored to provide one and two year projections for July 2015 to June 2016 and for July 2016 to June 2017. Biomass and exploitation rates were calculated for catch scenarios equal to the average landings for 2012-2014 (7,500 mt), and for a TAC of 12,000, 15,000, and 18,000 mt. Recruitment was assumed to be the mean of the model time series.

Figure 6 shows the projected population biomass and exploitation for the next two fishing years, using a catch scenario that assumes that landings will be equal to the average landings for the 2012-2014 fishing years (status quo). The biomass, exploitation and probabilities of the population declining below B_{MSY} are shown for the four catch scenarios for 2015-2016 in Table 2, and 2016-2017 in Table 3.

Table 2. Impact of four catch scenarios on projected biomass (x10³ mt) and fishing mortality estimates, and probability of population declining below B_{LRP}, July 2015 to June 2016 (CI – Credible Interval).

Landings Used for Projections (x 10³ mt)	Fishing Mortality	Median Biomass 2016 (x 10³ mt)	95%CI Biomass 2016 (x 10³ mt)	Probability of 2016 Biomass Falling Below B_{LRP}	
				50% of B_{LRP}	40% of B_{LRP}
7.5	0.064	118	81-161	0.041	0.001
12	0.112	113	76-174	0.059	0.003
15	0.144	112	73-173	0.072	0.003
18	0.164	107	70-168	0.087	0.005

[1] 7.5 x 10³ mt is the 2012 – 2014 average landings.

Table 3. Impact of four catch scenarios on projected biomass (x10³ mt) and fishing mortality estimates and probability of population declining below B_{LRP}, July 2016 to June 2017 (CI – Credible Interval).

Landings Used for Projections (x 10³ mt)	Fishing Mortality	Median Biomass 2017 (x 10³ mt)	95%CI Biomass 2017 (x 10³ mt)	Probability of 2017 Biomass Falling Below B_{LRP}	
				50% of B_{LRP}	40% of B_{LRP}
7.5	0.069	112	76-171	0.056	0.010
12	0.121	105	69-164	0.096	0.014
15	0.159	102	65-161	0.117	0.020
18	0.210	95	60-152	0.155	0.036

[1] 7.5 x 10³ mt is the 2012 – 2014 average landings.

Biomass is expected to decline and exploitation increase slightly in 2016 assuming that landings remain similar to those of 2012-2014. This is due to the strong 2013 and 2014 year classes, which are almost 3 times the average for the 1970-2014 time series. Biomass is projected to decline in 2016 and further in 2017 for all catch scenarios. However, population biomass is predicted to remain above the reference level of 80% of B_{MSY} in all cases, with the probability of falling below this threshold approximately 16% for catch scenarios up to 18,000 mt (Tables 2 and 3).

Conclusions

At the 2012 framework and assessment, it was concluded that Scotian Shelf Silver Hake biomass was above the Upper Stock Reference, and that fishing mortality was below the Removal Reference. Since that assessment of this resource, new information is available from two sources – commercial landings data and the results of the DFO Summer RV Survey. A Science Response was provided in 2014 updating the status of this resource (DFO 2015a). The current document updates the status of the resource, including 2014 landings data and the results of the 2015 Summer RV Survey.

Exploitation in 2015 was lower than projected in the 2014 assessment due to reduced landings and continued good recruitment with the appearance of the large 2014 year class at age 1.

Survey biomass declined in 2015, from 2014 when the highest biomass was observed since the mid 1980s, and is at a level comparable to those observed in 2009, 2010 and 2013.

The stock remains in a healthy zone, with biomass above the Upper Stock Reference, and fishing mortality likely below the Removal Reference.

The current TAC is appropriate given stock status. Assuming an average recruitment for the projected years, biomass is expected to fall as the 2013 and 2014 year classes diminish over time. However, population biomass in 2016 and 2017 will continue to be above 80% B_{MSY}.

Sources of Uncertainty

Only the RV survey strata 440-483 were used, excluding data from the Bay of Fundy. The stock boundary between the Scotian Shelf and Bay of Fundy Silver Hake stocks is imprecise and may vary from year to year.

Dynamics of a logistic biomass model may not closely track the dynamics of the population. The model assumes mean recruitment and growth across the projected years and does not account for the variability in year class strength. The ability of the model to describe future biomass more than one year ahead is uncertain give that Silver Hake have highly variable recruitment patterns and the fishery is based on recruiting individuals (Age 1 fish).

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Sources of Information

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